

The effect of proprioceptive exercises on static and dynamic balance in professional athletes

The effect of proprioceptive exercises on balance

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Abstract

Aim: In this study, we aimed to evaluate the effect of proprioceptive exercises on static and dynamic balance in professional athletes.

Material and Method: The study was designed with a matched-group using a pre-post design. Twenty professional male athletes (mean age: 20.55±3.55 years, Body Mass Index: 22.45±1.46 kg/m²) participated in the study. Proprioceptive exercises were performed 3 days per week with a physiotherapist and at home on the remaining days for the 6-week training period. After obtaining demographic information, static and dynamic balance parameters were evaluated using the Korebalance™ balance assessment equipment. Static and dynamic balance evaluation was performed while they were in the positions of eyes open, double/single-leg stance, and hands on-off; in addition, for static balance in the positions with closed eyes.

Results: Comparing balance parameters before and after proprioceptive exercise training, a statistically significant difference was found in all static balance parameters ($p < 0.05$). In addition, a statistically significant difference was found in the dynamic balance parameters in a double-leg stance position ($p < 0.05$), whereas no statistically significant difference was found in the dynamic balance parameters in a single-leg stance position ($p > 0.05$).

Discussion: The research results showed that proprioceptive exercises effectively improved static and dynamic balance in professional athletes. Thus, due to the integration of balance and the proprioceptive system, exercises will positively contribute to athletes' postural control capabilities by improving their balance performance. But, there was no effect on dynamic balance in one-leg stance position, so it would be beneficial to include in the training program exercises, which increase the dynamic balance in one-leg stance position.

Keywords

Proprioception; Balance; Exercise

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Introduction

Football is a type of sport that requires technical skills as well as static and dynamic balance. Most of these technical skills, such as juggling the ball in the air and passing, receiving, or dribbling the ball, require standing and balancing on one leg. Balance plays a crucial role during difficult conditions such as moving on slippery grass, changing the ball's orbit, pushing opponents, and facing footballers during a football game [1].

Balance is a highly integrated dynamic process involving multiple neurological pathways that require proprioceptive feedback. Many sports require superior balancing ability to achieve the highest level of competition [2]. Improvement in balance control is thought to be important for footballers and is based on a combination of mobility, power, and proprioception. Therefore, improvements in balance may lead to a better performance during football games [3]. Some research results suggest that proprioceptive ability is important for achieving higher balance skills in athletes [4]. Proprioceptive senses are related to the physical condition of the body and include stative, tendon, and muscle senses and pressure senses from the plantar. Therefore, the proprioceptive mechanism is necessary for proper joint functioning in sports, daily life activities, and some occupational skills [5, 6].

The purpose of a proprioceptive exercise program is to train the afferent pathways to increase the sense of movement and to make sure complicated movements are performed correctly without any hesitation or thought. Therefore, open and closed kinetic chain exercises should be added to the exercise program in an orderly manner [7]. Athletes would continue to perform balance exercises in proprioceptive exercise programs to increase motor function at the brain stem level. These programs should be implemented with standard progression, both with and without visual system input, and be specific to the activities and capabilities that the athlete needs [8].

Proprioception, a complex part of the neuromuscular system, is provided by afferent and efferent stimuli that allow both body balance and orientation to be sustained [9-11]. These stimuli are transported and interpreted under the control of the central nervous system, allowing the formation and maintenance of proprioception in sports activities. Previous studies have shown that improvement in balance performance, which plays an important role in sports physical fitness parameters, significantly improves footballers' body posture stability, increases performance, and protects against injuries [12-14]. Therefore, an improvement of proprioception in lower extremity joints through special exercises will lead to balance development in athletes, and thus will significantly affect their performances [7].

We hypothesize that proprioceptive exercises affect static and dynamic balance in professional athletes.

Material and Methods

Study Design

This study is an experimental study using a matched-group and a pre-post design investigating the effect of proprioceptive exercises on static and dynamic balance in professional athletes. Twenty professional male footballers from the Yeni Malatyaspor football club competing in the Turkish Super

League participated in the study.

The study population consisted of the athletes aged 15-29 of the football club Yeni Malatyaspor. All of the athletes who agreed to participate in the survey and met research inclusion criteria were included in the study sample without using any sample selection method. Assuming that the difference between pre-treatment (190.1 ± 42.1) and post-treatment (145.5 ± 25.7) double-leg stance static balance scores was determined as 44.6 in the power analysis with $\alpha = 0.05$ and $1-\beta$ (power) = 0.80 [15], it was calculated that at least 10 participants should be included in the study. The NCCS PASS 13 program was used to calculate the sample size.

Participants

Prior to participation in the present study, all individuals provided their informed consent. The experimental protocol was approved based on the ethical standards of the Declaration of Helsinki. In order to conduct this study, the required permission and consent was obtained from the Malatya clinical research ethics committee (Approval number=2016/177, Approval date =23/11/2016).

Following permission from the ethics committee, the research data were collected in the application laboratory of the Physiotherapy and Rehabilitation Department in the Faculty of Health Sciences at Inonu University and the Yeni Malatyaspor football club.

The individuals aged 15-29 years, licensed, able to adapt to the training program, volunteered to participate in the study, did not suffer from ankle instability, and signed the informed consent form were allowed to participate in the study. The athletes who suffered from systemic disease, experienced an injury in the last 6 months, refused to perform exercises, or had previous surgery were excluded from the study.

Procedures

Participants' demographic information including age, height, body weight, Body Mass Index (BMI), dominant side, and football experience were obtained. Following the pre-application evaluation, athletes were assigned two proprioceptive exercise sets 3 days per week for a 6-week training period under the supervision of a physiotherapist. They were asked to perform these exercises as at-home exercise on the remaining days. The athletes performed the exercises individually following the warm-up exercises before their regular training program. The athletes were carefully instructed to complete the warm-up process before starting the exercises. The exercises were carried out under the supervision of a physiotherapist from the Yeni Malatyaspor football club. Five different exercises lasting 10-15 minutes were assigned to each athlete. The exercises were carried out using a balance board, soccer ball, bosu ball, and small shuttle balance system.

The exercises were used moderately for the first 2 weeks, and as time progressed (Exercises were applied for 6 weeks; in the first 3 weeks- 2 sets of 15 repetitions; 4th week- 2 sets of 20 repetitions; 5th week- 2 sets of 25 repetitions; 6th week- 2 sets of 30 repetitions), the exercise program proceeded by exercising the ankle, knee, and hip joints at different joint angles. The participants performed proprioceptive exercises for a 6-week period to gradually improve the sensitivity and sensation of joint position in their trained joints. They also

practiced these exercises as at-home exercises.

Instruments

Static and dynamic balance parameters were evaluated before starting proprioceptive exercises and 6 weeks after the exercises using the Korebalance™ balance assessment and training equipment (Korebalance Premier-19 Systems Inc., USA) (Figure 1). The device calculates the total score, which includes deviations caused by impairment of postural balance. A higher total Korebalance score indicates poorer balance, while a lower total score indicates better balance [16]. Static balance evaluation was performed while participants were in the positions of eyes open-closed, double-leg/single-leg stance, and hands on-off, whereas dynamic balance evaluation was performed while they were in the positions of eyes open, double-leg/single-leg stance, and hands on-off.

Statistical Analyses

For analysis of the data, SPSS for Windows, Version 16, was used, and the mean ± standard deviation value for the variables was calculated. Because the data did not show a normal distribution, analyses were conducted using non-parametric tests. The Wilcoxon Signed Ranks Test was used because the repeated measurements were tested over the same sample. The significance level was set as p<0.05 in the analyses.

Results

Participant demographics

Twenty professional male athletes from the football club Yeni Malatyaspor participated in this study. The majority of athletes were right dominant (75%). Table 1 shows their demographic characteristics.

Table 1. Demographic characteristics

N: 20	X (SD)	Minimum	Maximum
Age (year)	20.55 (3.59)	17	27
Body mass index	22.45 (1.46)	18.02	25
Height (cm)	180.4 (5.84)	168	187
Weight (Kg)	73.15 (6.8)	60	82
Football experience (year)	8.22 (4.2)	3	17

Repeated measures

Comparing balance parameters before and after proprioceptive exercise training, a statistically significant difference was determined for all parameters of static balance (p<0.05). In addition, a statistically significant difference was found in the dynamic balance parameters in a double-leg stance position (p<0.05), whereas no statistically significant difference was found in the dynamic balance parameters in a single-leg stance position (p>0.05) (Table 2).

Discussion

The results showed that proprioceptive exercises positively contributed to the static and dynamic balance of professional athletes.

Proprioceptive loss and decrease in neuromuscular control cause functional instability in joints [9]. Proprioceptive exercises provide small but positive improvements in motor skills [17].

The ability to remain in balance during a single-leg or double-leg stance requires visual, neural, and vestibular integrity [18]. In the presence of an intact vestibular system, it is easy for people with closed eyes to stand due to the normal functioning of various proprioceptive receptors, such as mechanoreceptors in ligaments, Golgi tendon organ, and the muscle spindle [19]. Ankle proprioception is closely related to balance [2], however, there is a controversy regarding which balance parameters are affected by ankle proprioception [20]. A neuroimaging study reported that the central processing of proprioceptive signals from the foot and ankle complexes, beyond the peripheral reflex mechanisms, is essential for balance and postural control [21]. Footballers are known to have superior single-leg straight stance skills [22]. In the present study, the participants' low scores for static and dynamic balance in a single-leg stance are related to their high single-leg balance. The further development of this ability is an important factor for achieving greater success by footballers. The proprioceptive exercises carried out by athletes should be somewhat challenging to further develop these abilities [22]. The present study results indicated that even elite athletes' static and dynamic balance scores in the single-leg stance position improved due to

Table 2. Static and dynamic balance scores before and after treatment

N: 20		Pre-treatment	Post-Treatment	p	Z
		X (SD)	X (SD)		
Dynamic Balance	Right-leg stance, hands on, eyes open	3285.00 (800.18)	3274.05 (777.76)	0.911	0.112
	Left-leg stance, hands on, eyes open	3112.20 (755.85)	2902.65 (999.30)	0.145	1.456
	Double-leg stance, hands on, eyes open	1084.85 (634.52)	667.85 (383.84)	0.005*	2.837
	Double-leg stance, hands off, eyes open	1842.40 (516.15)	1438.65 (521.94)	0.011*	2.539
Static Balance	Right-leg stance, hands on, eyes open	154.25 (120.48)	106.30 (32.06)	0.042*	2.036
	Left-leg stance, hands on, eyes open	145.60 (66.38)	104.95 (39.50)	0.005*	2.800
	Double-leg stance, hands on, eyes open	175.85 (121.18)	110.25 (46.44)	0.005*	2.801
	Double-leg stance, hands off, eyes open	282.45 (147.65)	191.35 (101.62)	0.025*	2.240
	Right-leg stance, hands on, eyes closed	319.80 (149.13)	168.00 (88.46)	0.000*	3.771
	Left-leg stance, hands on, eyes closed	278.70 (165.32)	163.00 (61.89)	0.006*	2.763
	Double-leg stance, hands off, eyes closed	256.7 (118.19)	186.95 (46.58)	0.005*	2.800

*p<0.05

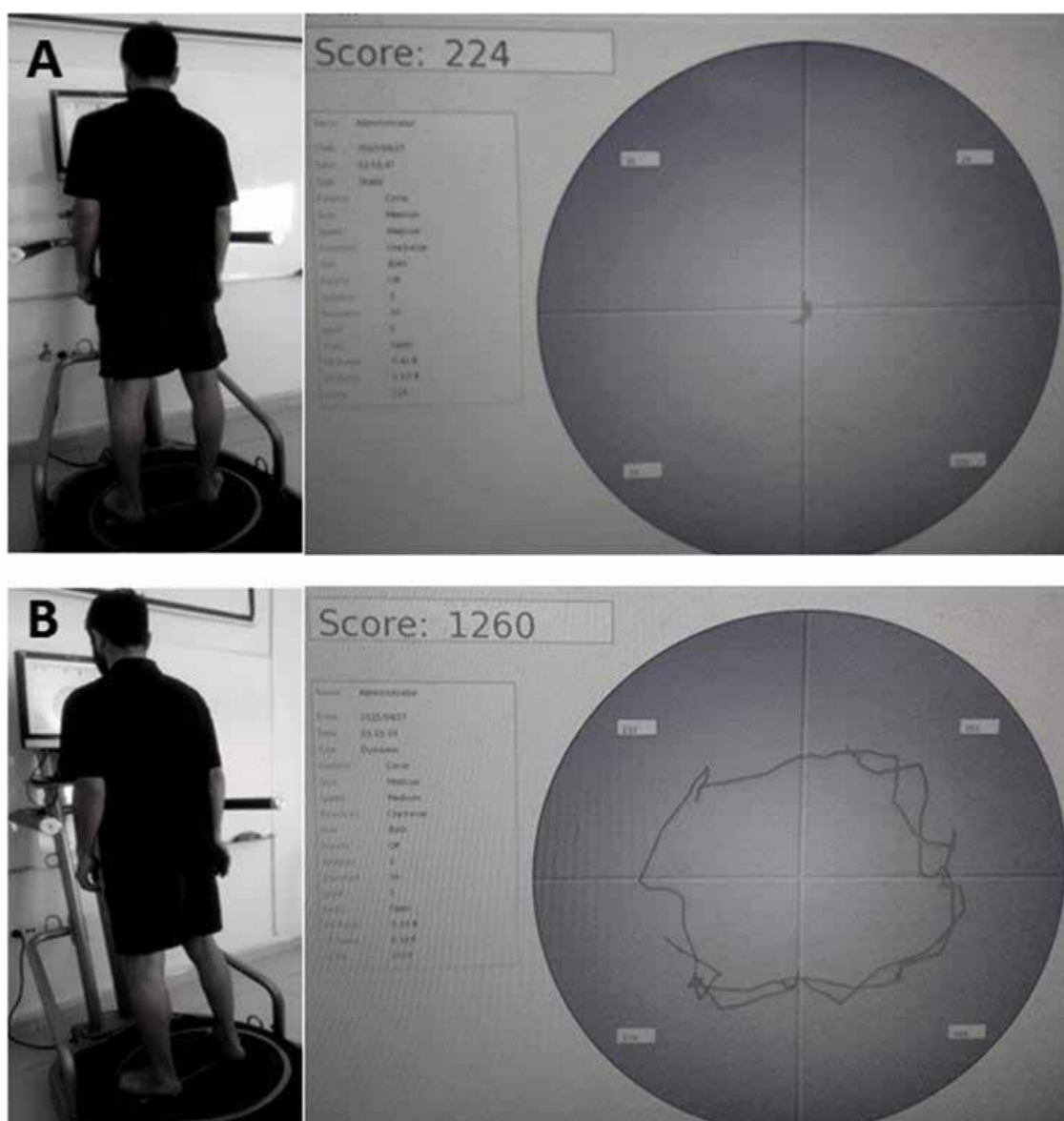


Figure 1. A: Static Balance Assessment (Double-leg stance, eyes open, hand off)
B: Dynamic Balance Assessment (Double-leg stance, eyes open, hand off)

proprioceptive exercise training. The difference between the pre- and post-training static balance scores in the single-leg stance was significant, whereas this difference for the single-leg dynamic balance parameters was not significant. Similar to the present study, Karakaya et al. found that ankle proprioceptive exercises positively affected static body balance parameters in healthy young college students [15]. Khuman et al. stated that footballers had better static and dynamic balance than other athletes, and they found no significant difference between static and dynamic balance in terms of lower extremity dominance [23]. The present study supports this result. Another study dynamically assessed balance using a single-plane balance platform and investigated the effects of a 6-week strength and proprioception training program on clinical balance in patients who had previously experienced a first-degree lateral ankle sprain. They found that the strength and proprioceptive training program improved participants' balance [24].

Han et al. stated that since the central processing of ankle proprioceptive information together with other sensory

information ensures the integration of posture and balance control [2]. In line with the literature, the present study results indicated that a 6-week proprioception exercise program improved both dynamic balance parameters (22% when eyes open and hands off; 39% when eyes open and hands on) and static balance parameters (33% with eyes open and hands off; 38% with eyes open and hands on; 28% with eyes closed and hands off). Similarly, Arslan et al. (2010) found that an 8-week proprioception training program improved dynamic postural control in taekwondo athletes [25].

A limitation of the study is that there is no standardization of proprioceptive exercises in the literature. This is an important limitation for studies in this area. However, we attempted to overcome this limitation by using proprioceptive exercises with predetermined efficacy from similar previous studies. Further studies that examine the efficacy of proprioception exercises, standardize them, and add dual task exercises are needed to improve single-leg dynamic balance.

Conclusion

Based on the results, the present study is the first study evaluating, in detail, all parameters of both dynamic and static balance in athletes before and after proprioceptive exercise training. The need for this study in the literature has been mentioned in the research limitation sections of previous studies [15, 23]. A lack or deterioration of the balance mechanism may adversely affect performance in athletes. The research results showed that proprioceptive exercises effectively improved static and dynamic balance in professional athletes. Thus, due to the integration of balance and the proprioceptive system, exercises will positively contribute to athletes' postural control capabilities by improving their balance performance. But, there was no effect on dynamic balance in one leg stance, thus it would be beneficial to include exercises, which increase the dynamic balance in one leg stance in the training program.

Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and human rights statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

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Conflict of interest

None of the authors received any type of financial support that could be considered potential conflict of interest regarding the manuscript or its submission.

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